Abstract
There is an ongoing debate in the scientific literature about the biomechanics, histopathology, prevalence, and pathophysiology of the constellation of cranial and ocular findings referred to as the Shaken Baby Syndrome (SBS). This paper presents a brief overview of the literature on SBS and details the debate that is raging. The results of this debate are already having a significant impact on child abuse litigation around the world.

In July of 2005, the London Court of Appeals overturned the convictions of three cases of a particular form of child abuse and accepted up to 90 more such cases for review.1 This decision calls attention to the rigorous debate raging in the scientific community about the constellation of child abuse findings labeled “The Shaken Baby Syndrome.” The fear of the consequences of shaking babies is etched into the back of many young parents’ minds and, due to public education by various experts and agencies, the Shaken Baby Syndrome (SBS) has become a commonplace term in both scientific and layman circles. However, within the past few years, many of the supposedly typical SBS findings have been questioned, and the quality of the evidence for the syndrome criticized. This has divided the scientific community into experts that continue to espouse the traditional or slightly modified views of this syndrome versus those that have begun questioning its foundations.

Child abuse has long been a part of human life, but SBS is a relatively new concept. It can be traced back to two publications in the early 1970’s by Caffey who described the constellation of findings in infants that had been shaken while held by the extremities.2,3 These findings included the presence of subdural hematomas and ocular hemorrhages due to a whiplash force and the absence of signs of external head trauma. Caffey referred this as “The Whiplash Shaken Infant Syndrome.” Many studies thereafter supported Caffey’s diagnosis and also added new findings, including the presence of perimacular retinal folds and traumatic macular retinoschisis as ocular lesions highly specific for the syndrome.4,8 By the 1980’s, these findings were being referred to as the now familiar “Shaken Baby Syndrome.”9

Although by the end of the last century questions were still being posed about the pathophysiology, mechanism, and true prevalence of SBS, the literature seemed to espouse a unified view of most of the critical aspects of the syndrome. A study by Duhaime et al. in 1986 found that blunt trauma was present in most supposed victims of SBS.9 Duhaime et al. also advocated, based on available biomechanical data from subhuman primates, that shaking alone was not enough to cause the SBS findings. Duhaime’s findings were, however, disputed by other studies, and the concept of SBS as a purely shaking based phenomenon remained.10,11 A more serious challenge to the prevailing beliefs about SBS was provided by numerous studies in the early 1990’s that disputed the diagnostic nature of many of the syndrome’s findings. Principal among these were ophthalmologic findings such as extensive subretinal, intraretinal, and preretinal hemorrhages. Even more specific findings such as folding of the retina around the macular region (perimacular retinal folds) and the separation of any of the retinal layers in the region of the macula (traumatic macular retinoschisis) were challenged. Although the differential diagnosis of retinal hemorrhages in infancy is quite broad, including hemorrhages from the birthing process as well as hemorrhages due to coagulopathies, retinal hemorrhages were not considered likely in short distance accidental falls.12 This was important because the most common history for SBS victims as given by the parent or guardian was one of an accidental household fall. The finding of retinal hemorrhages in these supposed accidental cases would point to shaking as the true cause of the injury.13 However, studies finding that retinal hemorrhages could be found after Cardio Pulmonary Resuscitation (CPR) raised concerns that children unconscious due to reasons other than abuse could be wrongly deemed to have been abused.14,15 Although retinal hemorrhages were no longer pathognomonic for SBS, numerous studies reconfirmed the high prevalence of SBS in infants with retinal hemorrhage.12,13,16,17 Other studies questioned the finding that CPR can cause retinal hemorrhages or indicated that CPR retinal hemorrhages, which are typically small punctate hemorrhages, were easily distinguishable from the characteristic pattern of SBS retinal hemorrhages which consisted of extensive, often confluent, hemorrhages found in subretinal and preretinal regions as well as extensively throughout the layers of the retina.18,19 Thus, despite many challenges, by the turn of the century, a somewhat uniform picture of SBS had emerged. Infants, usually below the age of two but sometimes up to the age of five, presenting with histories of accidental trauma who had little evidence of external head injury but who suffered from subdural and retinal hemorrhages were quickly scrutinized for the possibility of SBS if no other obvious causes, such as a severe coagulopathy, were found.20

Since 2001, many of the traditionally held beliefs about SBS have been called into question. Prior to 2001, the prevailing view was
that whiplash forces caused subdural hemorrhages through the rupture of bridging veins and retinal hemorrhages through the effect of these shearing forces on the well-adherent vitreoretinal junction in infants.\textsuperscript{17,21} A series of neuropathological studies brought into question this traumatic rupture mechanism. Autopsy findings indicated that the most common mechanism of cranial injury in supposed SBS cases was global hypoxic damage and eventual brain swelling leading to the bleed.\textsuperscript{22} Another study in 2003 by Donohoe presented a review of the SBS literature up to 1998 and found that there existed numerous errors in methodology and logic as well as misinterpretation of data.\textsuperscript{25} The studies examined were mostly retrospective in nature and Donohoe believed that the authors stretched their interpretations to fit pre-conceived notions about SBS. He concluded that the literature and thus the prevailing viewpoints on SBS did not appropriately fit the criteria for evidence-based medicine.

The neuropathology studies and the study by Donohoe laid the foundation for other researchers wanting to dispute the prevalent thinking about SBS. An article by Lantz \textit{et al}. accompanied by a series of editorials in a 2004 British Medical Journal (BMJ) issue were particularly critical.\textsuperscript{26} Lantz \textit{et al}. described a 14-month-old child with all of the supposed findings of SBS, including those deemed to be highly specific for the syndrome such as extensive retinal hemorrhages and perimacular retinal folds.\textsuperscript{28} All the other pieces of evidence in the case, including the corroborated accident history, however, pointed to accidental causes for the child's injury. An accompanying editorial by Geddes and Plunkett built on the Lantz article to question not just the diagnostic findings of SBS, but also whether enough evidence existed to even support a reasonable belief in the syndrome's existence.\textsuperscript{27} Plunkett had previously published a study in 2001 that found subdural and retinal hemorrhages in children with short distance falls from playground equipment.\textsuperscript{28} In their BMJ article, Plunkett and Geddes combined these results with those of Lantz and Donohoe to assert that a diagnosis of SBS is much less reliable than generally thought. The response to these BMJ articles was very strong. A letter was submitted to the BMJ signed by numerous experts on child abuse that refuted the articles of Donohoe, Lantz, Geddes, and Plunkett for committing to the BMJ. A letter was subsequently published in 2004 by Plunkett and Geddes \textit{et al}. accompanied by a series of editorials in a 2004 British Medical Journal (BMJ) issue, authors' reply. It was the response to these BMJ articles that brought into question this traumatic rupture mechanism. Autopsy findings indicated that the most common mechanism of cranial injury in supposed SBS cases was global hypoxic damage and eventual brain swelling leading to the bleed. Another study in 2003 by Donohoe presented a review of the SBS literature up to 1998 and found that there existed numerous errors in methodology and logic as well as misinterpretation of data. The studies examined were mostly retrospective in nature and Donohoe believed that the authors stretched their interpretations to fit pre-conceived notions about SBS. He concluded that the literature and thus the prevailing viewpoints on SBS did not appropriately fit the criteria for evidence-based medicine.

Experts in the field have an opportunity to make a significant contribution by continuing to conduct objective and more advanced biomechanical and pathological research in the attempt to come closer to the truth on SBS. Allowing child abusers to escape justice or innocent parents and guardians to be falsely accused of abusing children are both serious miscarriages of justice.

\textbf{References}


14. Weedn VW, Mansour AM and Nichols MM. (1990). Retinal hemorrhage in an vegetative child with all of the supposed findings of SBS, including those deemed to be highly specific for the syndrome such as extensive retinal hemorrhages and perimacular retinal folds.\textsuperscript{28} All the other pieces of evidence in the case, including the corroborated accident history, however, pointed to accidental causes for the child's injury. An accompanying editorial by Geddes and Plunkett built on the Lantz article to question not just the diagnostic findings of SBS, but also whether enough evidence existed to even support a reasonable belief in the syndrome’s existence.\textsuperscript{27} Plunkett had previously published a study in 2001 that found subdural and retinal hemorrhages in children with short distance falls from playground equipment.\textsuperscript{28} In their BMJ article, Plunkett and Geddes combined these results with those of Lantz and Donohoe to assert that a diagnosis of SBS is much less reliable than generally thought. The response to these BMJ articles was very strong. A letter was submitted to the BMJ signed by numerous experts on child abuse that refuted the articles of Donohoe, Lantz, Geddes, and Plunkett for various reasons but failed to provide any new data to support their claims.\textsuperscript{29} The response to Reecie from Geddes, Plunkett, and Lantz followed in subsequent BMJ issues but once again reiterated old findings and failed to address the fundamental issues of the debate with any new data.\textsuperscript{30,31}

The mere fact that this debate exists, however, has had a monumental impact on child abuse litigation. Ophthalmologists can no longer claim in the court that a child has been abused because of the presence of retinal findings he/she believes is specific for SBS. Defense lawyers for those suspected of causing SBS assert that there is disagreement between the experts and, therefore, the court should not use ocular findings as proof of abuse.\textsuperscript{1} Influenced largely by the published BMJ articles, the diagnosis of SBS has been called into serious question in Britain and elsewhere. The Judge in the three SBS cases overturned in July 2005 felt that the court should take more notice of a changing scientific theory.\textsuperscript{1}